PART 7249

$1.00

HANDBOOK
OF
OPERATION and SERVICE

MODEL 263 and 293

VIBROGROUND

TRADE MARK REGISTERED

MP MASTER

MA30284

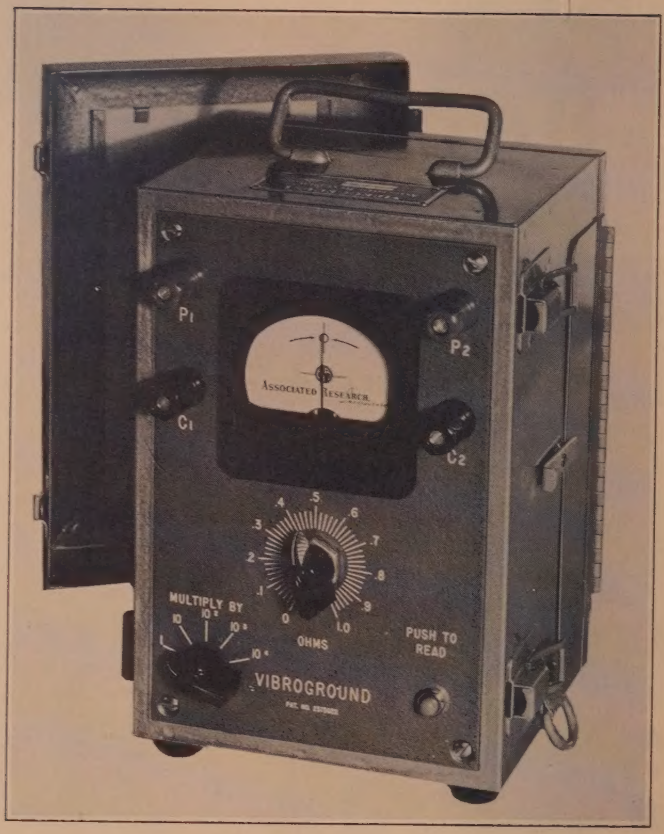
ASSOCIATED RESEARCH, Incorporated

Precision Test Instruments

3758 W. Belmont Ave. Chicago 18, Illinois

2M 861

Copyright 1961



Model 293

NOTE

The Model 263 VIBROGROUND is used as an example throughout this manual. The Model 293 is identical to the 263 in physical appearance and operation, and has all the ranges of the 263 with one additional higher range. The ranges of Model 263 are 0-1/10-100/1000 ohms and of the 293, 0-1/10/100/1000/10,000 ohms.

The Model 293 "Multiply By" range switch, unlike the Model 263, is calibrated in powers of 10 (multiply by 1, 10, 10^2, 10^3, 10^4). The Model 293 resistivity range is more than 20 million ohms per cubic centimeter at 10 feet or greater probe spacing.

In this manual, all references to the Model 263 apply equally well for the Model 293, except for the differences outlined above.

TABLE OF CONTENTS

SECTION	I	INTRODUCTION	1
SECTION	II	OPERATION	3
	2-1	Principles of Operation	3
	2-2	Set-up for Operation	5
	2-3	Determination of Resistance	6
	2-4	Earth Resistivity Measurement	7
	2-5	Man-Made Ground Resistance Measurement	11
	2-6	Circuit Resistance Measurement	17
SECTION	III	MAINTENANCE	17
	3-1	Batteries	17
	3-2	Vibrator	18
	3-3	Condensers	18
	3-4	Resistors	18
	3-5	Balancing Meter	19

SECTION I

INTRODUCTION

1-1. This handbook covers operation and service instructions applicable to the Model 263 VIBROGROUND. This instrument is a self-contained synchronous vibrator, battery powered unit which is capable of measuring earth resistivity or the true resistance to earth of man-made grounds, irrespective of the earth's resistance and condition. It is not affected by the resistance of the auxiliary probes or leads. Polarization effects are reduced to a minimum. Stray A.C. or D.C. currents in the earth do not detract from its accuracy. No outside power source is necessary. Its accuracy is not influenced by the accuracy of the indicating meter but is dependent upon the accuracy of a calibrated resistor.

1-2. In the Model 263 VIBROGROUND four resistance ranges, 0 to 1 ohm, 0 to 10 ohms, 0 to 100 ohms, 0 to 1,000 ohms are capable of selection.

1-3. The Model 263 VIBROGROUND provides means for obtaining accurate measurements by the following methods.

1-3.1. Four Electrode Method, for determination of average earth resistivity. The ranges provided in the instrument make possible accurate soil resistivity measurements from 0 to 1,915,000 ohms per cubic centimeter at 10 ft. or greater spacings. Current density determinations are also possible.

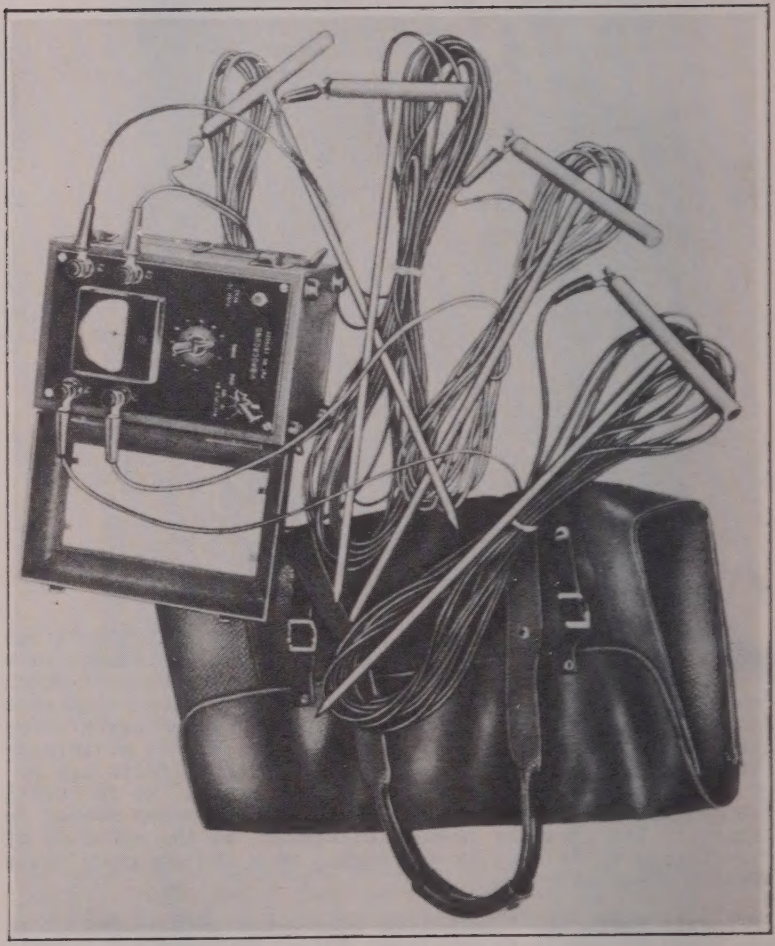


Figure 1-1 -- Complete view of Model 263 VIBROGROUND with #7105 Test Kit

1-3.2 Three Electrode Method, for the measurement of resistance to earth of man-made grounds, anode resistances, polarization effects.

1-3.3. Two Electrode Method, for the measurement of circuit resistance.

1-4. The Model 263 VIBROGROUND is manufactured by Associated Research, Incorporated, 3758 West Belmont Avenue, Chicago 18, Illinois.

SECTION II

OPERATION

2-1. PRINCIPLES OF OPERATION.

2-1.1. The Vibroground works on a null-balance principle of operation. The voltage drop developed by a current flowing through the unknown ground resistance is measured by comparing it to a portion of the voltage drop developed by that same current flowing through a calibrated potentiometer.

2-1.2. The instrument consists of a power supply, a current supply circuit and a measuring circuit. The power supply changes the low DC battery voltage (B) by means of a 97 CPS synchronous vibrator (V) to an alternating current, which is fed to the primary transformer T_1. This voltage is stepped up to 125 volts AC in the secondary of T_1. In the current supply circuit, the secondary of the transformer T_1 is connected in series with a calibrated potentiometer and terminals C_1 and C_2 which connect to the two current electrodes (driven into the earth). The resistance of the earth between these two current electrodes completes the circuit.

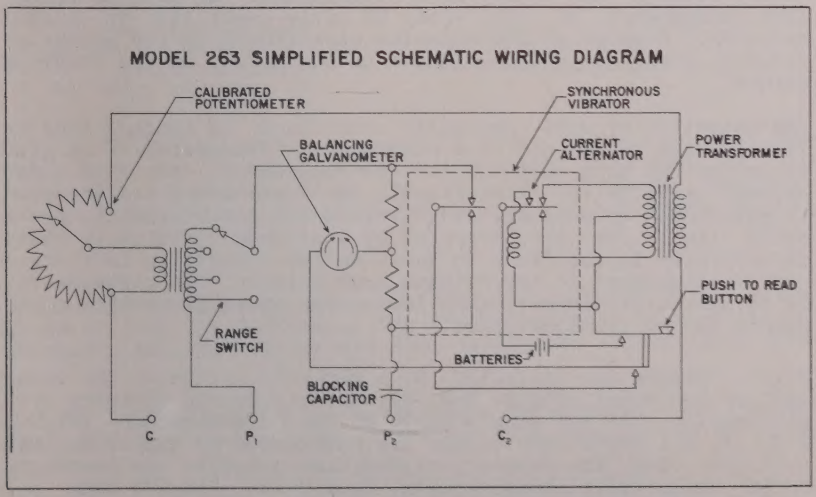


Figure 2-1 -- Simplified schematic wiring diagram of Model 263 VIBROGROUND

2-1.3. The measuring circuit consists of a secondary of the ratio transformer T_2 and its associated range selector switch S_2, two metering resistors R_1 and R_2, the galvanometer M and a blocking capacitor C (to prevent stray DC entering the measuring circuit), and two terminals P_1 and P_2 which connect to the two potential electrodes (driven into the earth between the two current electrodes). The resistance of the earth between these two potential electrodes completes the circuit.

The current flowing between the two current electrodes causes a voltage drop across the ground resistance between the two potential electrodes. This voltage drop causes a current flow in the measuring circuit. The current flowing through the calibrated potentiometer causes a voltage drop which is fed to the primary of the ratio transformer. This induces a voltage drop in the secondary of the ratio transformer, also causing a current flow in the measuring circuit. This current tends to cancel the current due to the voltage drop across the ground resistance. When the calibrated potentiometer and selector switch are adjusted so that the two currents exactly cancel, the galvanometer will indicate balance by resting in the zero position. The resistance reading on the calibrated dial of the potentiometer, multiplied by the range switch setting, then gives the value of the earth resistance between the two potential electrodes connected to P_1 and P_2.

2-1.4. Since there is no current flowing in the measuring circuit at balance, the resistance of the potential leads has no effect on the reading. Since the same current that flows through the ground causes the voltage drop on the potentiometer P_1, the resistance of the current leads connected to C_1 and C_2 are also relatively unimportant. Since the meter current is rectified by the synchronous vibrator at 97 CPS, only current at that particular frequency can cause a meter indication. The unit is therefore independent of any stray 60 cycle power line or ground currents. Because of the blocking capacitor C in the potential circuit, stray DC ground voltages have no effect on the readings either.

The detection of zero potential condition is accomplished in Vibrogrounds by the use of a D'Arsonval galvanometer. This galvanometer has been selected for its ruggedness, accuracy and extreme sensitivity. Electrically the instruments are designed to withstand a substantial overload in their circuits for a short time. They are protected by a stepped sensitivity shunt incorporated in the "Push to Read" button circuit to facilitate coarse adjustment to approximate zero balance. The galvanometer is automatically electrically locked for extra protection of its pivots during transportation.

2-1.5. Ranges are selected by a separate switch at the lower left of the panel (Figure 2-2, 3). Special design features permit reading, on the single scale of the potentiometer (Figure 2-2, 1). All resistance values are determined by simple decimal multiplication. The ranges provided make possible the reading of earth resistivity measurements from 0 to 1,915,000 ohms per cubic centimeter at 10 ft. or greater spacings. The resistance

of man-made grounds under average conditions fall within the ranges of the instrument. Resistance measurements of single or multiple anodes installed in the earth, also fall within the ranges of the instrument.

2-1.6. Condensed field operating instructions are contained in the instrument cover.

2-2. SET-UP FOR OPERATION.

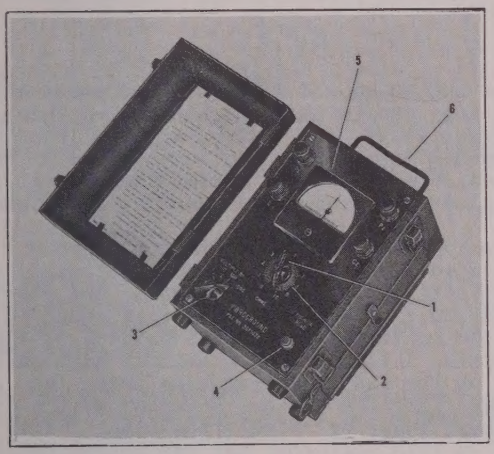


Figure 2-2 -- Panel view of Model 263 VIBROGROUND

1. Potentiometer knob.
2. Potentiometer scale for reading resistance.
3. Range selecting knob.
4. Push to read button.
5. Balancing meter.
6. Carrying handle.

2-2.1. With the instrument lying in front of you so that the cover locks are at its right side, unlatch and open lid. To remove lid, push away from you which will release the slip hinges. The lid can then be removed from the instrument during testing.

2-2.2. For field test work the case is provided with two eye rings so that the instrument may be conveniently carried by employing a shoulder strap with snap fasteners. (Figure 3-2, 10.)

2-2.3. Depending upon the measurement to be made, the instrument will be connected in accordance with the following paragraphs.

2-2.4. To close up the instrument, repeat in reverse the process referred to above.

2-3. DETERMINATION OF RESISTANCE.

2-3.1. It is advisable to begin testing with the range selector switch (Figure 2-2, 3) set in the high range or "1000" position. The potentiometer knob should be turned to its most clockwise position as shown in (Figure 2-2, 1). This setting provides resistance of 1,000 ohms on the internal resistance leg of the bridge.

2-3.2. Depress the small button (Figure 2-2, 4) approximately halfway to the panel and observe the deflection of the pointer on the meter (Figure 2-2, 5).

NOTE

The push button should always be depressed halfway during preliminary adjustments. This reduces sensitivity of instrument and protects galvanometer against violent overswings. When depressed to full travel, maximum sensitivity is then employed for final potentiometer adjustment.

2-3.3. If the pointer deflection is to the right of the meter dial, the resistance is within the measurement range of the instrument. The potentiometer knob should be slowly turned counter-clockwise until the meter pointer is centered. At this point observe the position of the knob pointer on the engraved potentiometer scale. If it is positioned at a point on the scale engraved on the panel approaching zero, the resistance range is too high and the range selector switch should be shifted to the next lower or "100" position. With the range selector switch in this position, and the potentiometer knob on the extreme clockwise position, again depress the push button and adjust the potentiometer knob as before. If the pointer on the meter cannot be centered again until the knob indicates a position approaching zero the range is again too high and the next lower range should be worked as described previously. If the meter pointer cannot be centered within the "10" range, again repeat the operation with the range selector switch in the "1" position.

2-3.4. The function of the range selector switch is to furnish various multiplier circuits to permit reading of ohmic values from 0 to 1,000 when in the "1,000" position; 0 to 100 when in the "100" position; 0 to 10 when in the "10" position and 0 to 1 when in the "1" position. Thus assuming that the potentiometer knob pointed to .4 indication on the panel scale with the range switch in the "1000" position, then the ground resistance would be 400 ohms. If the same potentiometer reading were obtained with the switch in the "100" position, the resistance would be 40 ohms; with the range switch in the "10" position resistance would be 4 ohms; with the range switch in the "1" position, the resistance would be .4 ohms.

2-3.5. As soon as the pointer of the meter has been centered in any of the ranges, depress the push button all the way to the panel for full sensitivity. Again center the meter pointer

with the switch in this position by re-adjustment of the potentiometer knob. Assuming that the meter pointer was able to be centered with the range switch in the "10" position and the potentiometer knob pointer set at the ".12" indication on the panel scale, the resistance measurement being made would be 1.2 ohms. If the potentiometer knob pointer were located halfway between the ".12" and the ".14" panel designations at the time the meter pointer were centered and the range switch in the "10" position, then the ground resistance would be 1.3 ohms. In this way it is possible to accurately read the resistance of any value within the range of the VIBROGROUND by interpolation of the setting of the potentiometer pointer and the range switch.

NOTE

It will be impossible to observe any meter pointer deflection if external electrode circuits are open due to disconnected or broken leads.

2-4. EARTH RESISTIVITY MEASUREMENT.

2-4.1. In the field of corrosion studies pertaining to buried objects and conducting or circuit carrying materials, which come in contact with the earth, the resistivity of such earth is of prime importance.

2-4.2. The use of earth resistivity measurements in Geophysical Prospecting and the determination of subsurface strata is a well-known and accepted practice. Variation of electrode spacings, and configuration, over the area under consideration provides a wealth of information. The problems of such measurements are those of the Geophysist. No attempt is being made to cover this highly specialized field in this manual.

2-4.3. Although several methods have been employed to determine earth resistivity the most satisfactory method has resulted from the use of an instrument such as Model 263 VIBROGROUND. With this instrument the earth resistivity can be determined in ohms per unit volume generally accepted as ohms per cubic centimeter.

2-4.4. The average earth resistivity of a given area can be most easily measured by the use of the Model 263 VIBROGROUND, four electrodes and the necessary connecting leads. Where desired, an auxiliary test kit No. 7105 consisting of a suitable carrying case, four 18" rods, two short leads of equal lengths and two long leads of equal lengths, (lengths to be specified when ordering), can be supplied at extra cost. (See Figure 1-1.) In determining average earth resistivity by the Four Electrode Method, the spacing "a" between electrodes P_1 and P_2 controls the average depth to which the average earth resistivity is being determined. (Figure 2-3.) It is therefore essential that this spacing be maintained accurately at all times and particularly where many readings are being taken over a wide area at spacings as determined by the depth penetration to which it is desirable to take readings.

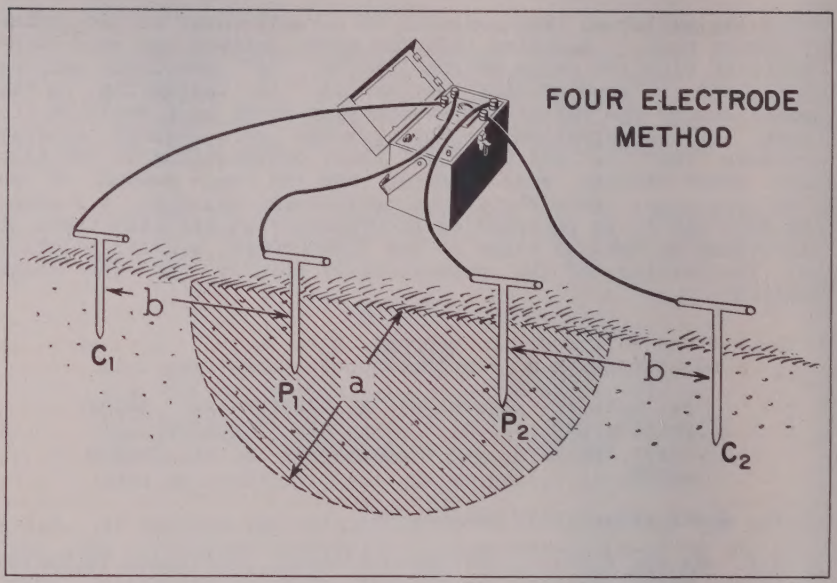


Figure 2-3 -- Diagram of proper test probe placement for four electrode method.

2-4.5. The calculated soil resistivity (P) will be the average to a depth "a" when "b"="a" (Fig. 2-3). If distance "b" is greater than "a", the resistance reading (R) will decrease. When "b" is less than "a", the resistance reading (R) will be greater than when "b"="a". For conditions where "b" does not equal "a", the soil resitivity (P) in ohms per cubic centimeter is correctly calculated by the formula:

$$P = \frac{95.76\ bR}{1 - \frac{b}{b+a}} \text{ (with dimensions in feet)}$$

2-4.6. Soil resistivity in ohms per cubic centimeter (P) equals 2 pi times the distance between the potential electrodes P_1 and P_2 in centimeters (a) times the reading of the instrument in ohms (R).

$$P = 2\pi aR \text{ (with "a" in centimeters)}$$
$$P = 191.5\ aR \text{ (with "a" in feet)}$$

For the recommended condition with "b"="a", the following table is provided. Readings taken at greater spacing can be obtained by applying the formula as given above.

Distance between P_1 and P_2 in feet	Multiplier times R in ohms
1	191.5
2	383.0
3	574.5
4	766.0
5	957.5
6	1149.0
7	1340.5
8	1532.0
9	1723.5
10	1915.0

The average soil resistance or earth resistivity between P_1 and P_2 is obtained with no electrode contact resistance included.

2-4.7. In conjunction with cathodic protection, current density can be readily determined by the use of the four electrode method wherein measurement of resistance between two potential electrodes at right angles to the structure is taken. Then measure the potential difference between the same two electrodes with a potentiometer voltmeter. Calculate current circulating in the area under test by applying Ohm's Law.

2-4.8. In the VIBROGROUND, the measured resistance in the four electrode method is that of a hemisphere of soil of radius "a" (Figure 2-3), measured from two points on the circumference of the hemisphere and distance "a" apart. The outside current electrodes (C_1 and C_2) introduce a current into the soil. This current creates an I R potential drop through the soil which is contacted by the potential electrodes, and is counter-balanced internally in the instrument by a current through a calibrated variable resistor.

2-4.9. If the underground pipe line were within the field measured by the potential electrodes it would offer a lower resistance path between them than the earth itself. Thus the resistance reading would be low and erroneous. The potential electrodes should be at least 1/2 "a" from the pipe line.

2-4.10. The only effect of the current electrodes being too close to the pipe line would be to make the potential indications weaker and thus harder to determine a null balance. In this case the resistance reading would not be erroneous, only more difficult to obtain. It is always better practice to place the measuring electrodes in a line perpendicular to the pipe line, rather than in a line parallel to it.

2-4.11. Although earth resistivity measurements are usually considered in connection with cathodic protection, the additional advantages of this instrument for the measurement of anode resistance should not be overlooked. These readings may be obtained by the Three Electrode Method wherein terminals C_1 and P_2 are considered as one connection but to be used together by separate leads to the anodes (see Figure 2-4). The distance "b" affects the readings in the same manner as with the Four Electrode Method. The proper distance "b" can be determined in

the same manner. Be certain that C_1 and P_1 have separate leads to the anode being measured, otherwise the resistance of leads to C_1 will be included.

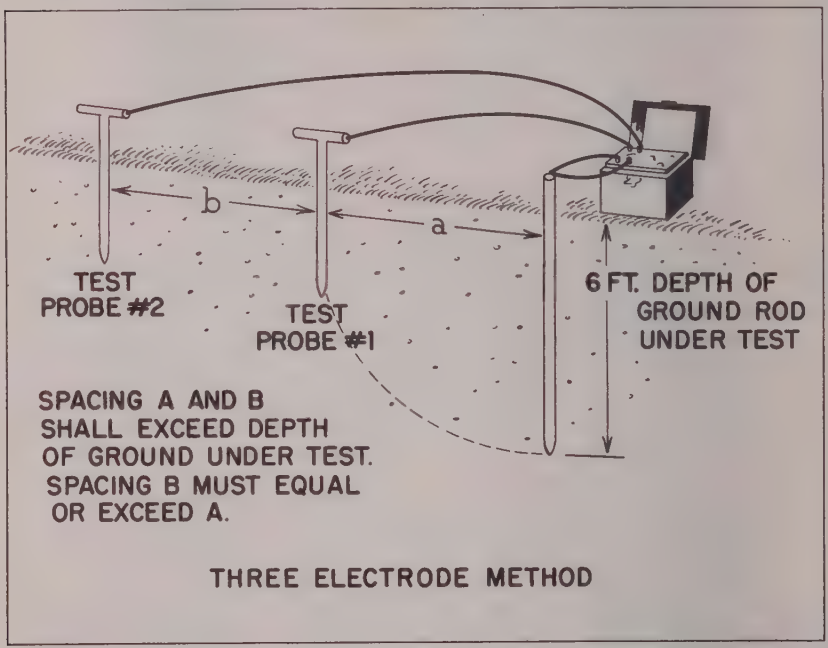

b
a
TEST PROBE #2
TEST PROBE #1
6 FT. DEPTH OF GROUND ROD UNDER TEST
SPACING A AND B SHALL EXCEED DEPTH OF GROUND UNDER TEST. SPACING B MUST EQUAL OR EXCEED A.
THREE ELECTRODE METHOD

Figure 2-4 -- Diagram of proper test probe placement for three electrode method

2-4.12. Using this method the internal resistance of the soil to a depth of "a", soil contact resistance of anode and internal resistance of anode will be obtained. Soil contact of electrode P_2 is not included in readings which result from this measurement.

2-4.13. To determine polarization effects, the Three Electrode Method can be used before and after cathodic protection has been applied. Resistance measurements can be made with the Model 263 VIBROGROUND while cathodic protection is being applied.

2-4.14. Circuit resistance between anodes can be obtained by using Model 263 VIBROGROUND as 2 electrode instrument (Figure 2-5). By using the instrument in this manner, be certain that C_1 and C_2 have separate leads to anodes from those used for P_1 and P_2, otherwise the resistance of these leads will be included. When using the Model 263 in this manner, it is possible to obtain the internal resistance of both anodes, soil contact resistance of both anodes, and soil resistance between anodes to a depth equal to "a".

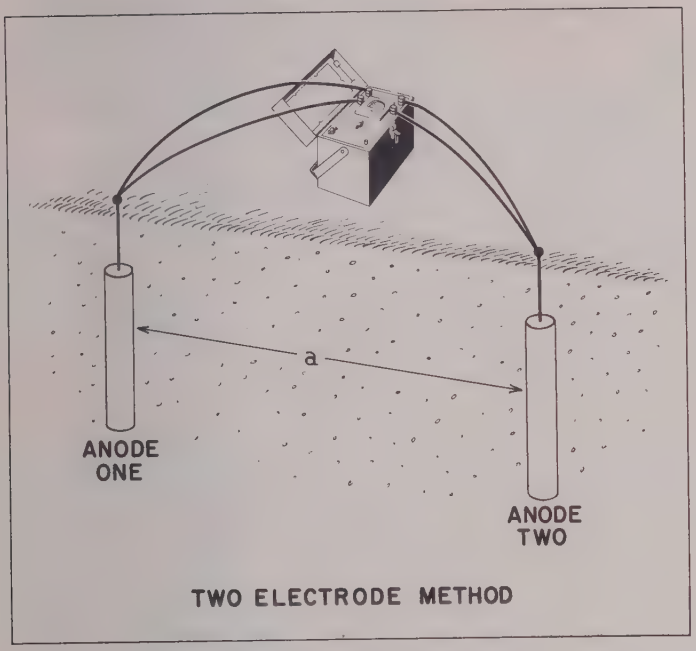


Figure 2-5 -- Diagram of proper test probe placement for two Electrode Method

2-5. MAN-MADE GROUND RESISTANCE MEASUREMENT.

2-5.1. In electricity, the earth is considered to be the point of lowest potential. Therefore, any material capable of conducting an electrical current, when connected to the earth by means of a conductor, also is at zero potential since any voltage existing in the material will be carried to the earth. Thus, if a power transmission tower, motor frame or metallic conduit is sufficiently well grounded, it cannot maintain a potential which might be established either through direct connection to a power source or by induction.

2-5.2. The quality of a man-made ground varies greatly depending upon the characteristics of the earth itself at the point at which the man-made ground is actually established. Clay and mud generally provide the best ground connections since they are dense in structure and generally contain sufficient moisture and metallic salts to render them conductive. Loosely packed sand or rock will be less conductive than the same material which is tightly packed. The amount of moisture in earth in which a ground is being established is of great importance. A relatively high moisture content is extremely desirable. The presence of mineral salts will also aid in the establishment of a good man-made ground.

2-5.3. The maximum of ground resistance allowable for different purposes varies according to the principle established in Ohm's Law ($R = \frac{E}{I}$). For example, the maximum allowance resistance to ground of a power transmission tower carrying 10,000 volts at 1,000 amperes would be 10 ohms. ($R = \frac{E}{I}$: $R = \frac{10,000}{1,000}$: $R = 10$) If this condition were existant, there would be no possibility of any potential being carried in the tower framework which might be caused by a short between the power line and the tower structure. In actual practice it is always necessary to have a lower resistance than the actual maximum resistance allowable in order to carry off the normal load voltage. This extra capacity of the man-made ground assures against potential being carried in the unit due to possible line surges or extra potential introduced outside of the normal circuit by such as lightning.

2-5.4. In the measurement of ground resistance with most instruments it is necessary that the presence of stray A.C. or D.C. current in the ground under test be eliminated from calculations before establishment of an accurate ground resistance reading is made. In the VIBROGROUND this has been done by means of the circuit employed and readings of ground resistance are accurate without the requirement for any further calculation. It is necessary in all cases to be sure to isolate the made-ground under test. To do this, the user of the VIBROGROUND must make sure that the unit to which the ground is attached is not in any way attached to another ground. The best way to accomplish this is to disconnect the ground which is to be tested from its connection to the equipment which it is serving as a ground and make test of the ground itself while it is disconnected. As a further check for other ground connection of the unit to which the ground is normally attached, the VIBROGROUND should be connected to the equipment and a reading taken before the tested ground is reattached. If the test shows a relatively low ground resistance, the test would indicate the presence of another ground connection being made to the equipment either accidentally or by design. The presence of a secondary ground will in no way be detrimental and is recommended especially in cases where large voltages are encountered.

2-5.5. The VIBROGROUND is not affected by the resistance of either the test leads or the test probes used for the test. For simplicity, test kit No. 7105 (Figure 1-1) is recommended for earth resistivity measurements and test kit No. 7104 for measurement of man-made grounds.

2-5.6. In testing ground resistance it must be remembered that while the resistance between the actual ground and the grounding medium (pipe or rod, etc.) is negligible, the conditions set up in the establishment of the ground must be taken into careful consideration if an accurate test is to be made. The earth around the grounding point may be considered as a series of uniformly concentric (if the earth is of homogenous structure) sections or irregularly shaped sections (if homogeneity is not found). The diagram (Figure 2-6) shows how these

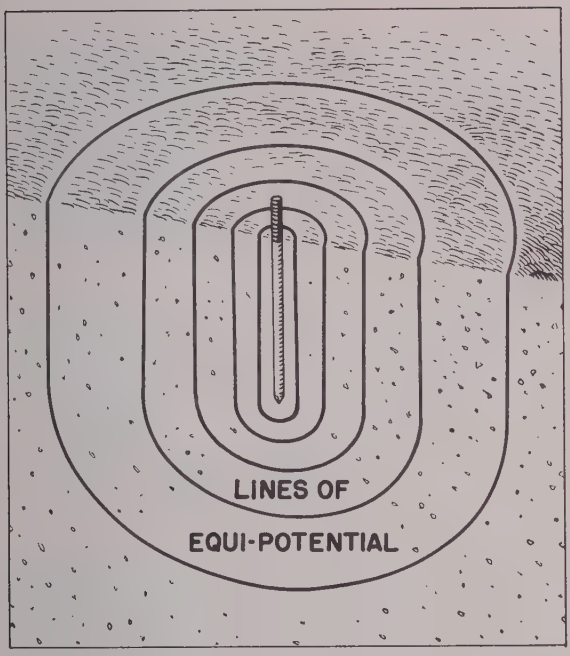


Figure 2-6 -- Diagrammatic sketch of lines of equi-potential in homogenous ground.

sections of uniform potential and consequent resistance will exist as they surround a ground rod. The largest drop in potential will occur in a minimum section immediately surrounding the man-made ground. This effect lessens rapidly with the addition of succeeding sections, becoming fairly constant in a short distance. In (Figure 2-4), where a simple rod is driven to a depth of six feet, it is necessary that the test probes be placed in the ground at a distance in excess of the depth of the driven ground if an accurate measurement of resistance is to be made. The reason for this lies in the radial effect of the depth of the ground on the earth surrounding the rod or pipe. Whenever the depth of the driven ground to be measured is unknown, always allow more than enough distance between the first driven test probe and the ground under test to insure against this radial effect. In actual practice, the operator must be careful to get the two test probes properly spaced and positioned to avoid possible inaccuracies in reading. A good rule is to place the probes at uniformly spaced distances and on a straight line away from the ground under test.

2-5.7. Often metal masses are buried to form a better ground. If such grounds are being tested, it will be necessary to determine the depth and area of these grounds and then place the first test probe outside of the radius formed by the depth and outside limit of the buried mass as shown in (Figure 2-7).

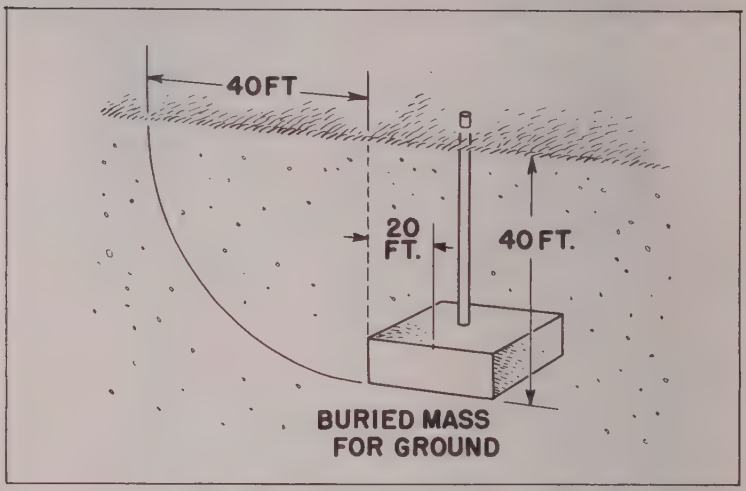


Figure 2-7 -- Diagram of method of determining proper distance for test probe placement when using buried mass for ground.

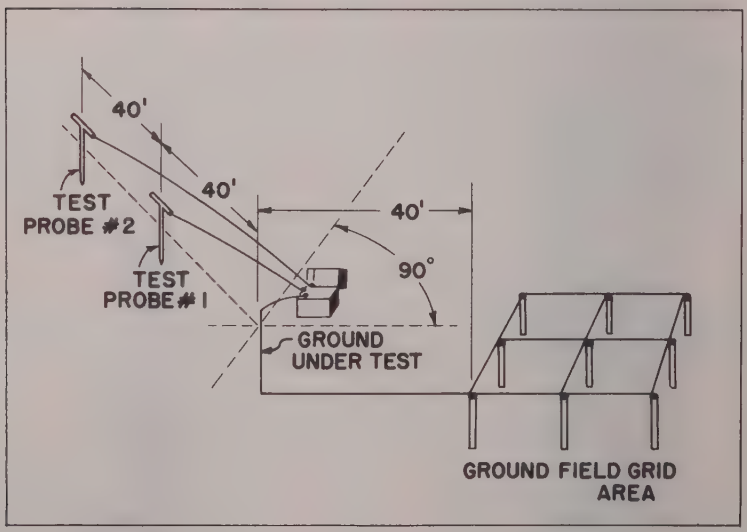


Figure 2-8 -- Diagram of placement of test probes for testing "grid" ground field.

2-5.8. At times grounds will be formed by a grid of driven or buried grounds as shown in (Figure 2-8). In such instances it is necessary that the test probes be placed outside the actual ground area after this area has first been thoroughly established as to location and size. For greatest accuracy in such cases, place the potential electrode P_2 a distance from the ground under test equal to five times the length of the longest diagonal of the area covered by this ground. The current electrode C_2 should then be place a minimum of 100 feet or more further away. Greather electrode spacings, if possible, will afford greater accuracy of reading.

2-5.9. In testing a man-made ground it is often impossible to determine accurately soil conditions of the ground. Often the location of a buried ground bed is indeterminate. Should abnormally low resistances be encountered, a safe check is to increase the spacings of the auxiliary test probes until a point is reached where the readings observed do not appreciably change. If readings are taken of a ground rod at same spacing but on different radii and the readings vary, it can be assumed that the correct resistance is the average of the readings taken.

2-5.10. In the measurement of a power line ground for instance, always set the test probes on a line which is at right angles to the direction of the line. If the ground of a corner pole of such a line is being tested, first try to set the probes on the bisector of the outside angle formed by the line as shown in (Figure 2-9). If this is impossible, then the probes should be placed on the line forming the bisector of the inside angle. The reason for such placement is to eliminate any possibility of inaccuracy through induction.

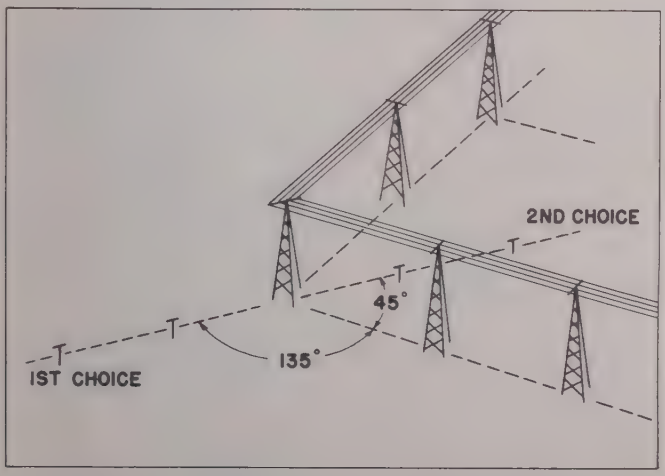


Figure 2-9 -- Diagram of test probe placement for testing corner tower of power line to avoid induction error.

2-5.11. It will oftentimes be found advisable to employ the use of a previously established ground such as a water system or other easily available and well established grounds. This is particularly useful in checking grounds on equipment located inside buildings. When such procedure is found to be advisable then the Model 263 instrument would be used as a 2 electrode instrument by connecting C_1 and P_1 together and C_2 and P_2 together and in turn, connecting them to this common ground as illustrated in (Figure 2-10).

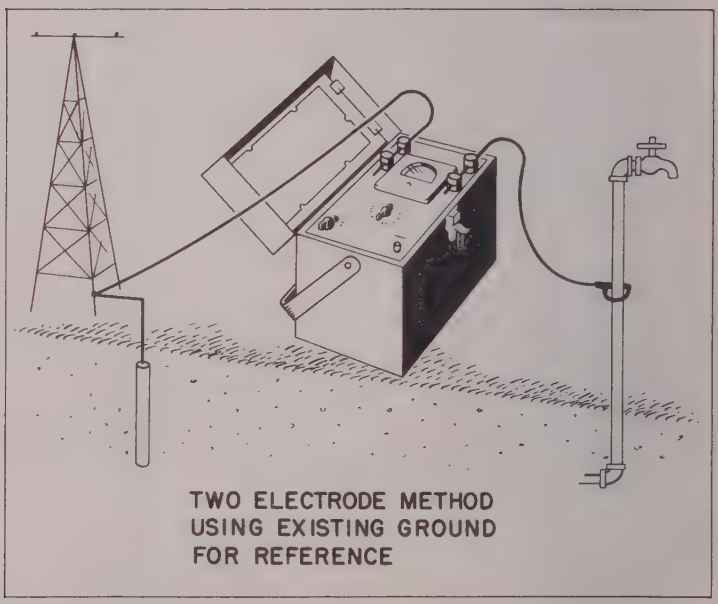


Figure 2-10 -- Two electrode method using existing ground for reference.

2-5.12. If absolutely accurate readings are desired, P_1 and C_1 should be connected to the grounds under test by separate leads whereas terminals P_2 and C_2 may be connected together and then to the low resistance ground. Readings may then be taken as described in paragraph 2-5.11.

2-5.13. When the nature of the ground prohibits the driving of test probes into the surface, a satisfactory pair of auxiliary grounds can be made by use of two 1 ft. square pieces of metal which are placed on the surface of the earth and firm contact established between earth and plates. Use of wet dirt and brine mixture is recommended to establish this contact with the hard surface. Test leads are then attached to plates and connected in the usual manner to the VIBROGROUND. Usually any grounds of this type will be of high resistance unless the rock or hardpan has high mineral content.

2-6. CIRCUIT RESISTANCE MEASUREMENT.

2-6.1. Model 263 VIBROGROUND may be used for measuring approximate resistance of coils, transformers, resistors or other items comprising resistance within the range of the instrument. To obtain these readings the two-point method is employed by shorting binding posts P_1 and C_1 together and binding posts P_2 and C_2 together and connecting the resistor under test between these two pair of shorted binding posts.

SECTION III

MAINTENANCE

3-1. BATTERIES.

3-1.1. Model 263 VIBROGROUND is made so as to require a minimum of maintenance. In general usage, it will only be required that the batteries be replaced from time to time as their power deteriorates through time or use. If the vibrator ceases to

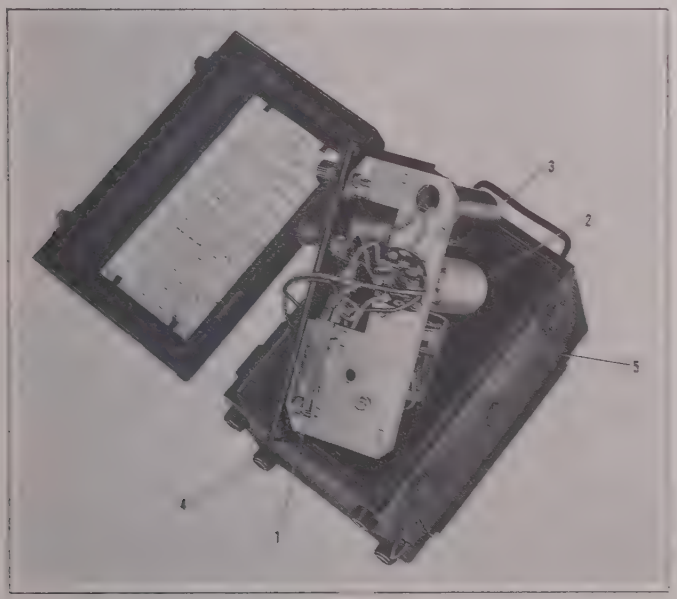


Figure 3-1 -- View of under side of panel and chassis.

1. Stack switch.
2. Vibrator.
3. Electrolytic condenser.
4. Rubber feet.
5. Battery compartment door.

operate or readings become erratic, it can usually be assumed that the batteries are exhausted. As accuracy and operation of the instrument is independent of normal battery voltage, batteries may be used until no longer able to actuate vibrator. To replace the batteries, rotate the catch on the side of the instrument to a horizontal position and open the door (Figure 3-1, 5) which is held by this catch. Grasp the thumb-nut just inside the door and pull the sliding tray forward (Figure 3-2, 13). This tray (Figure 3-2, 12) is so arranged that it can be pulled out sufficiently far enough to remove the 8 #2 dry cells from their respective clips. In replacing these cells make sure that the same polarity is observed as that of the cells which were originally supplied in the instrument. Note: If VIBROGROUND is to be stored for long periods, remove batteries.

3-2. VIBRATOR.

3-2.1. In the event that the instrument fails to hum or no vibration can be felt when the stack switch button is depressed, it is possible that the vibrator (Figure 3-1, 2) has failed. Before replacing the vibrator, check the batteries. If the batteries are found to be in good condition, remove the instrument from its case by removal of the four screws located in the corners of the panel and lift out the panel and chassis which is attached to the panel. First check the stack switch (Figure 3-1, 1) for contact between the points when the push button is depressed. If the switch is in good operating condition, it is likely that the vibrator has failed and it must be replaced. In the event that the vibrator replacement fails to operate and the vibrator is known to be in operating condition, it is possible that the wiring is at fault and the wiring should be checked in accordance with diagram (Figure 3-3). Vibrator is clamped into a standard pin base socket.

3-3. CONDENSERS.

3-3.1. In rare instances it is possible that one of the electrolytic condensers (Figure 3-1, 3) used in the circuit will have broken down through improper application of current into the instrument. Condensers may be removed and checked with the use of any capacity tester, making sure that proper polarity is observed during test.

3-4. RESISTORS.

3-4.1. All of the resistors employed in this instrument are worked well within their range and therefore should not fail. Rarely, it will be found that the resistor has failed due to abuse through improper handling. Any of the carbon resistors can be replaced from commercial stock. If one of the wire-wound calibrating resistors is found to have been damaged, it will be necessary to replace it with a factory matched part. (Figure 3-2, 1.)

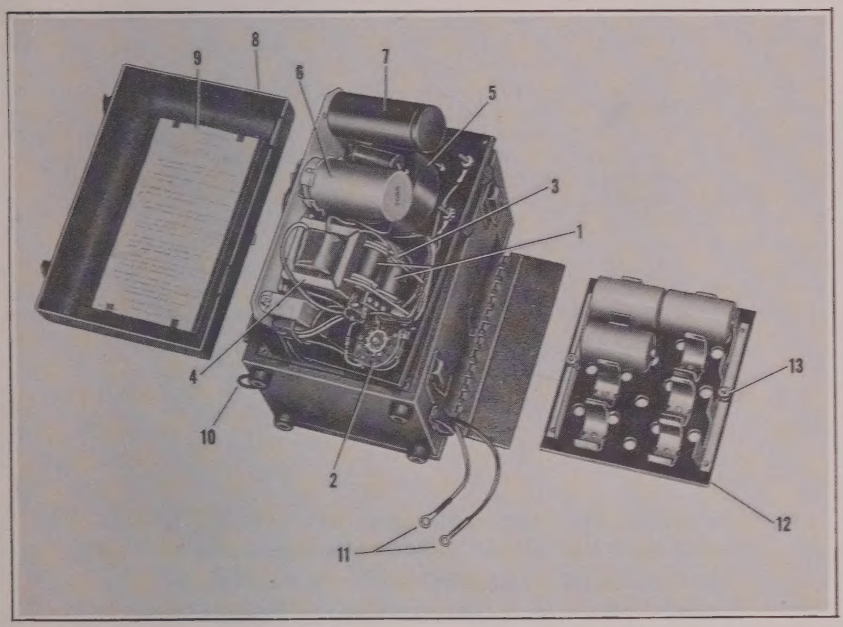


Figure 3-2 -- Second view of under side of panel and chassis.

1. Calibrating resistors.
2. Range switch.
3. Potentiometer.
4. Power transformer.
5. Meter.
6. Vibrator.
7. Electrolytic condenser.
8. Removable cover.
9. Instruction card.
10. Eye rings for carrying strap.
11. Battery leads.
12. Battery compartment drawer.
13. Battery terminal.

3-5. BALANCING METER.

3-5.1. The meter employed in the bridge circuit of this unit is manufactured specially for this instrument. Occasionally it will be damaged by dropping the entire instrument. In such an event, it should only be worked on by a competent instrument repair man. Damage will most likely occur to either the jewel mounting of the shaft of the moving coil or the pinion or balancing springs. No attempt should be made to repair this unit by anyone other than instrument specialists. The manufacturer maintains a repair service for instruments and it is recommended that damaged units be returned to the factory for repair.

FACTORY WARRANTY

VIBROGROUNDS are guaranteed free from defects in workmanship and material for one year from date of shipment provided Owner's Registration Card is returned within fifteen days from receipt of unit and there is no evidence of tampering or abuse.

This Warranty does not cover tubes, batteries or accessories not of our manufacture.

Any unit found defective under this guarantee will be repaired or replaced free of charge if returned to the factory PREPAID and insured.

ASSOCIATED RESEARCH, INC.
3758 W. Belmont Avenue, Chicago 18, Illinois

Printed in U.S.A.

MP MASTER
MA30284